Nekton as Indicators of Estuarine Restoration Success in a Tidal Creek and Lagoon

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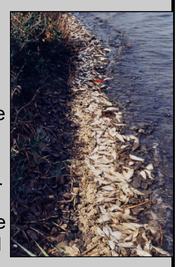
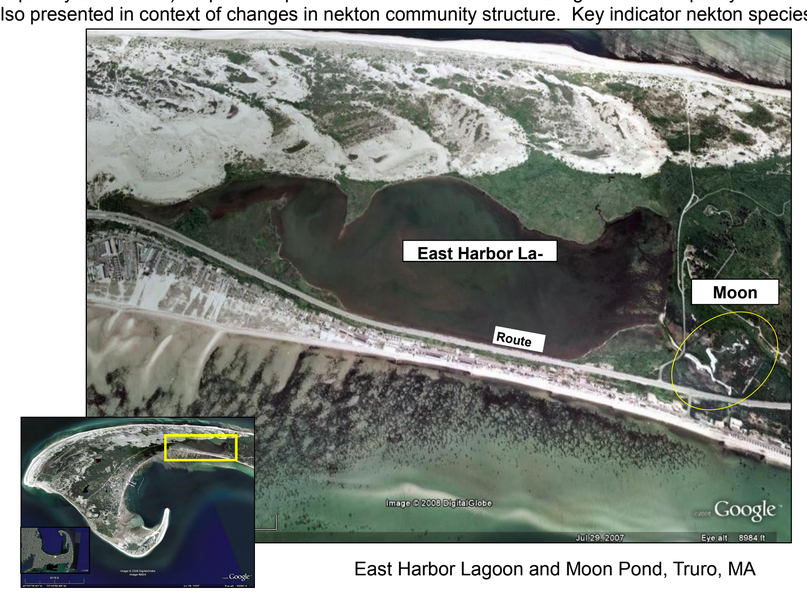
Abstract:
As part of the North East Coastal Barrier network vital signs monitoring, Cape Cod National Seashore has been conducting nekton sampling in tidally restricted ecosystems. Due to their high mobility, nekton are frequently monitored to assess the success of a tidal restoration. We present nekton monitoring data from East Harbor and Moon Pond, a freshwater lagoon and wetland, respectively, which were partially restored in 2002. We analyzed a suite of metrics (species richness, diversity, salinity tolerance, density, and length frequency distribution) for pre- and post- restoration nekton data. Long term water quality monitoring is also presented in context of changes in nekton community structure. Key indicator nekton species and

Background:
In 1868, East Harbor, a 700-acre back-barrier salt marsh and coastal lagoon in Truro, MA was cut off from tidal flow by construction of a causeway. A brackish/freshwater system developed and various surveys between 1911 and the 1970's reported salinities from 4-10 ppt. During this time, a mostly freshwater faunal community such as carp, eels, and shiners resided in the system. By the late 1960's and early 70's, ecological and water quality problems became apparent in East Harbor in the form of high turbidity, eutrophication, cyanobacterial blooms and chironomid midge outbreaks. In September 2001, a massive fish kill of alewife (*Alosa pseudoharengus*) and white perch (*Morone americana*) prompted the experimental opening of a 1.2 m diameter, 213 m long drainage pipe; this connection to the sea was permanently opened the following year (Thelen and Thiet, 2008). The system is presently considered partially restored as the salinities in the lagoon have dramatically increased yet the tidal fluctuations are almost imperceptible due to the small size of the culvert as compared to the volume of water in the lagoon. In addition, a box culvert and weir under a road crossing further restricts tidal flow to the lagoon. The tidal creek system upstream of the box culvert experiences a substantially higher tidal range than the lagoon (~0.5 m) and is referred to as Moon Pond (Portnoy *et al.* 2006).

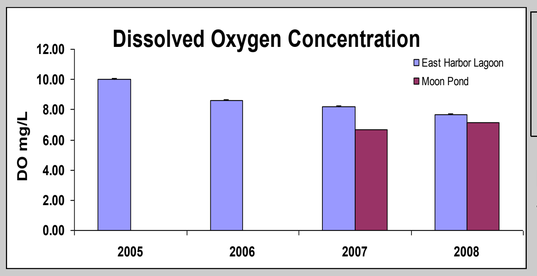


Methods:
Sample Design
- Nekton were sampled at randomly selected sites in East Harbor Lagoon (EHL) and Moon Pond (MP) using 1m^2 throw traps and 10m seines.
- Numbers of sampling sites varied from year to year, ranging between 15-30 throw trap sites and 1-4 seining sites
- Nekton were enumerated and identified to species
- The length of the first 15 individuals of each species was measured and recorded

Sampling Period
- Sampling frequency varied from 1-2 times per summer, densities were calculated on an annual basis



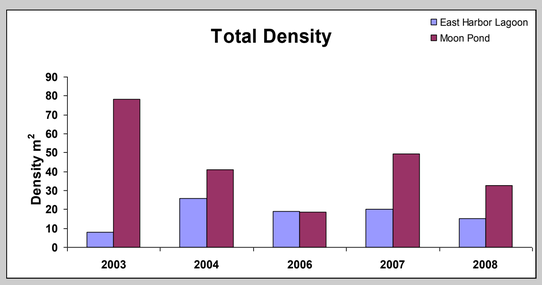
East Harbor Lagoon and Moon Pond, Truro, MA



Year	Average dissolved oxygen East Harbor Lagoon Range	Moon Pond Range
2005	0.42 - 20.89	na
2006	0.05 - 29.30	na
2007	2.31 - 20.12	0.52 - 12.23
2008	1.04 - 15.56	1.15 - 11.56

Nekton Density

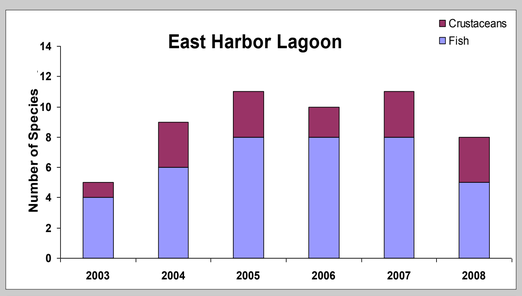
- Extremely high densities in MP in 2003 and 2004 were due to *Palaemonetes* sp.
- High density in MP in 2007 was due to *Crangon*
- Total nekton density in EHL has remained temporally consistent since 2004 and is similar to other marsh systems (Raposa, 2002; Roman *et al.* 2002). MP densities are relatively high

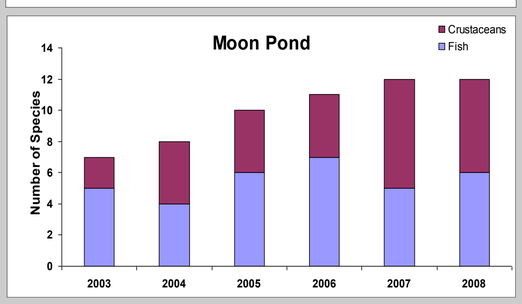


Fourspine stickleback,

Sand shrimp, *Crangon septem-*

Grass shrimp, *Palaemonetes* sp.



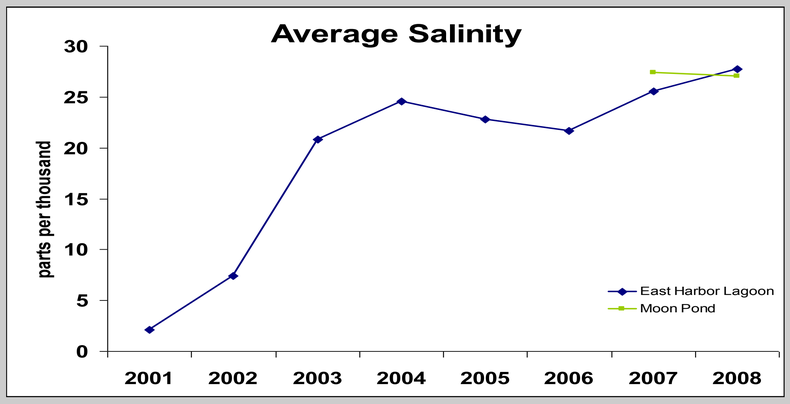


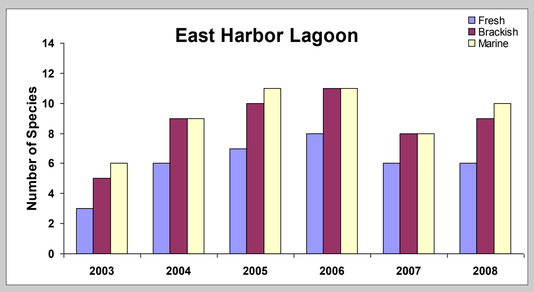
Species Richness

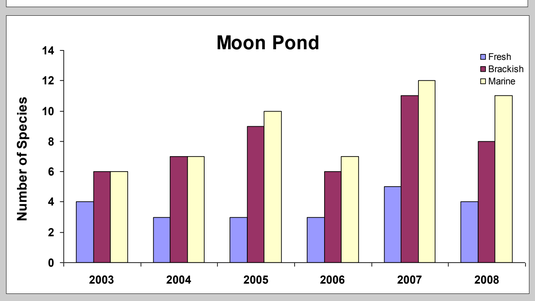
- Data collected from 1m^2 throw trap sampling events
- General increase in richness over time, especially in MP
- Number of crustacean species tended to stay consistent in EHL but increased with time in MP
- MP had a higher proportion of crustaceans than EHL
- Several crab species have appeared in MP in recent years including lady crab, *Ovallipes*

Longwrist hermit crab, *Pagurus longi-*

Lady crab, *Ovallipes ocel-*

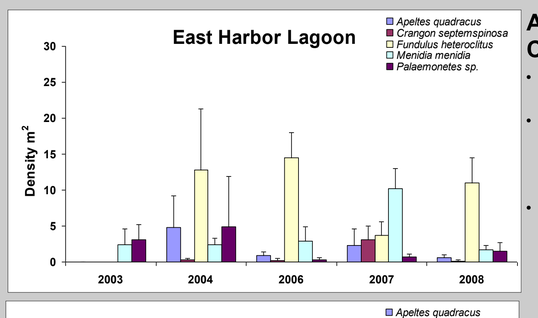


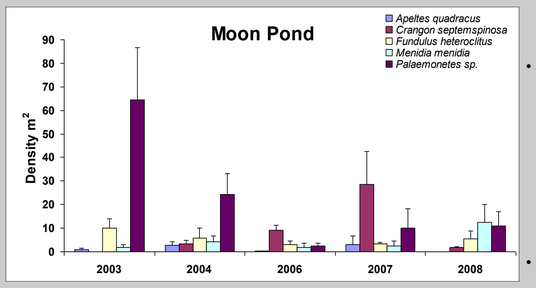




Salinity Tolerance Among Nekton Species

- Graph depicts number of species and their saltwater tolerance/affinity
- Salt tolerance categories were not exclusive
- Increase in number of species with brackish and marine tolerance with time following the partial restoration
- Two species affiliated with marine conditions were recorded for MP in 2008, winter flounder, *Pseudopleuronectes americanus* and *Tautogolabrus* sp.



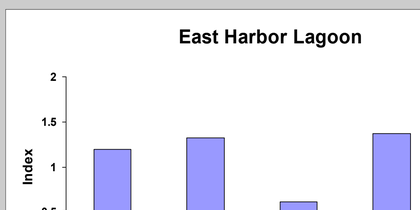


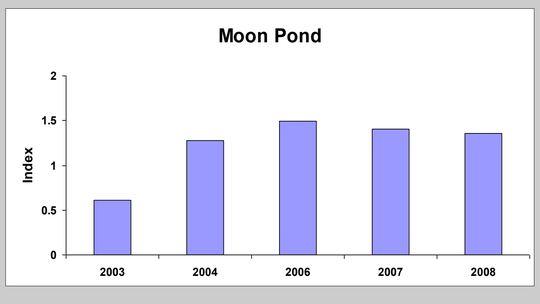
Average Density of Common Species

- Data was compiled from 1m^2 throw traps
- The five most commonly found species in both EHL and MP are shown
- Densities of *Fundulus heteroclitus* are similar those reported by Raposa and Roman (2001) and Roman *et al.*(2002) for nearby salt marshes
- Densities of *Palaemonetes* sp. in EHL are similar to other studies (e.g. Roman *et al.* 2002), but for MP, our results were much higher, especially in the two years following restoration
- Densities of *Crangon* in MP for 2006 and

Dominance by mummichogs (*Fundulus heteroclitus*) is consistent with other eastern US marsh systems (e.g. Raposa and Roman, 2001; Roman *et al.*

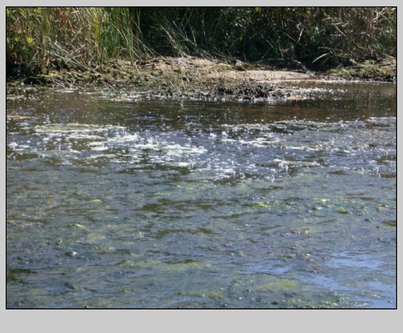
Densities of silversides (*Menidia menidia*) esp. in EHL are much higher than Raposa and Roman (2001) and Roman *et al.*





Shannon-Wiener Species Diversity

- Data was complied from 1m^2 throw traps only
- There were no throw trap sampling events in 2005
- Species diversity is higher in MP than in EHL and it appears relatively stable in MP from two years post-restoration
- Generally, the values reported for this study are similar to other studies where this calculation was performed (e.g. Upchurch and Wenner, 2008)



Silversides, *Menidia menidia*, at surface of Moon Pond.
Photo courtesy of Steve Smith, NPS

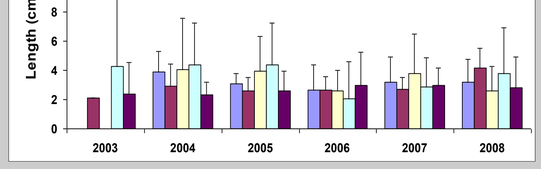
Observed Nekton Species

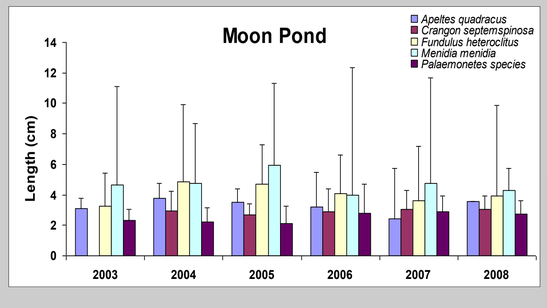
Prior to 2003	East Harbor Lagoon 2003 - 2008	Moon Pond 2003 - 2008
Alosa pseudoharengus	*Anguilla rostrata*	*Anguilla rostrata*
Anguilla rostrata	*Apeltes quadracus*	*Apeltes quadracus*
Cyprinus carpio	*Fundulus heteroclitus*	*Fundulus heteroclitus*
Morone americana	*Gasterosteus aculeatus*	*Menidia menidia*
	Menidia menidia	*Morone americana*
	Pseudopleuronectes americanus	*Panopeus herbstii*
	Pungitius pungitius	*Pseudopleuronectes americanus*
	Syngnathus fuscus	*Pungitius pungitius*
	Carcinus maenas	*Syngnathus fuscus*
	Crangon septemspinosa	*Tautogolabrus* sp.
	Palaemonetes sp.	*Carcinus maenas*
		Crangon septemspinosa
		Dyspanopeus sayi
		Libinia sp.
		Ovalipes ocellatus
		Pagurus longicarpus
		Palaemonetes sp.
Finfish		
Crustacea		

Species Composition

- Greater number of species observed for MP as compared to EHL is likely due to:
  - higher salinities
  - greater tidal range
  - proximity to the coast
  - changing substrate types (mud to sand)
- Species composition, especially the most dominant species, is similar between this study and others in the region (e.g. Raposa and

Conclusions:
- Nekton are good indicators of restoration success because their high mobility allows them to rapidly respond to changes in habitat conditions
- Nekton community in MP and EHL (species composition, richness, density of fish) resembles that of other similar systems in the region
- Changing species composition and relative abundance in MP likely due to changing environmental conditions and shift in predominant substrates (mud to sand as increased tidal flow removed fine sediments)
- Comparatively high crustacean densities in MP through time likely driven by substrate shift and future sampling likely to show continued declines in crustaceans





Average Species Length

- Data complied from 10m seines and 1m^2 throw traps
- Average size of *Fundulus* esp. in EHL is smaller than that of Raposa and Roman (2001) but MP is similar to Raposa (2002)
- Average size of *Menidia* is similar in EHL to Raposa (2002) but in MP *Menidia* are lar-

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